

Preliminary Amendment
August 16, 2001

Divisional of Appln. No. 09/476,208

REMARKS

Claims 1-5, 14-23 have been cancelled. The specification has been amended to correct certain informalities thereof as done in the parent case. Claims 12 and 13 have been amended to correct dependency and Claims 24 to 35 have been added to more particularly point out and distinctly claim the subject matter which the applicant regards as his invention.

The above amendments are believed to place the claims in proper condition for examination. Early and favorable action is awaited. Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "**Version with markings to show changes made.**"

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Respectfully submitted,
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Attachment: Version with markings to show changes made

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

Please replace the paragraph beginning at line 12, page 4, with the following rewritten paragraph:

A polishing surface plate 122 having a polishing pad 123 is disposed at a position that faces with the pattern formation surface 124a of the wafer 124 on the suction table 125. The polishing pad 123 rocks or [oscillate] oscillates in the same direction as the movement of a rocking table 121, since the polishing surface plate 122 is held by the rocking table 121.

Please replace the paragraph beginning at line 19, page 4, with the following rewritten paragraph:

Moreover, a polishing agent supplying nozzle 127 for supplying a polishing agent to the pattern formation surface is provided. The polishing agent is supplied by the polishing agent supplying nozzle 127 between the pattern formation surface 124a and the polishing pad 123, and at the same time, at least one of the vacuum suction [table] tables 125 and the polishing surface plate 122 moves upward and downward direction 300A to cause the polishing pad 123 moving in response to rocking movement of the rocking table 121 and the wafer 124 rotating in response to the rotation

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of the rotary table 126 to contact, thereby polishing the pattern formation surface 124a (the upper most film formed on the upper layer of pattern layers) on the substrate 124.

Please replace the paragraph beginning at line 18, page 5, and continuing of page 6, with the following rewritten paragraph:

Fig. 8(a) shows a state wherein an oxide film or membrane 92 is formed on a substrate 93 such as a wafer and recess or concave portion 90a has been formed in the oxide film by an etching, thereafter, a metallic coat 91 is formed on the oxide film by a sputtering of aluminum. Fig. 8(b) shows the state wherein said chemical and mechanical polishing is thereafter practiced on a product shown in Fig. 8(a). In Fig. 8(b) a dish-like portion D1 is created by dishing above the concave portion 90a when the width of the concave portion 90a is not less than $2\mu\text{m}$. Dishing as shown in Fig. 8(b) is caused when a pattern in which a plurality of concave portions or recesses 90b are periodically arranged is formed on a substrate and the metallic coat 91 is coated on the pattern. In this case, if a chemical and mechanical polishing is practiced on the coat, a large dish-like portion D2 is created by dishing above the concave portions 90b as shown in Fig. 9(b). Accordingly, when a wafer mark M including a line and space pattern formed by periodically arranging convex portions 90c as shown in Fig. 9(c) is used, a large dish-like portion D3 is created by dishing above the wafer mark M. For this reason, [a] an observed image of the wafer mark is distorted when it is detected by the alignment system and accuracy of alignment is reduced.

Please replace the paragraph beginning at line 16, page 7, with the following rewritten paragraph:

Another object of the present invention is to provide [a] an exposure method which does not create a dish-like portion on an alignment mark even when a flattening process is performed on the alignment mark (wafer mark).

Please replace the paragraph beginning at line 22, page 7, with the following rewritten paragraph:

The further object of the present invention is to provide a polishing apparatus which can symmetrize the film thickness of every [patterns] pattern when the film (particularly alignment mark) above the patterns is ground thereby.

Please replace the paragraph beginning at line 13, page 8, with the following rewritten paragraph:

A mask formed with an original pattern of alignment mark together with a pattern to be transferred according to the present invention, is structured such that the original pattern of said alignment mark is formed by disposing, between adjacent [blight] bright portions having a width of

not less than a predetermined value, one or more [blight] bright patterns having a width of less than said predetermined value with a pitch less than said predetermined value.

Please replace the paragraph beginning at line 22, page 11, with the following rewritten paragraph:

Fig. 4 is a structural view showing an alignment sensor of [an] a LSA system and [an] a LIA system used in the projection apparatus shown in Fig. 3.

Please replace the paragraph beginning at line 5, page 13, with the following rewritten paragraph:

Fig. 3 shows a schematic structure of a projection exposure apparatus adapted to be applied with the exposure method according to the present invention. In Fig. 3, an illumination light IL emitted from a high pressure mercury-vapor lamp 1 is reflected by an elliptical mirror 2 and is once collected at a second focal point, and thereafter enters into an illumination optical system 3 including a collimator lens, an interference filter, an optical integrator (fly-eye lens), and an aperture stop (σ stop). Although the fly-eye lens is not shown, it is arranged within a plane perpendicular to an optical axis such that a focal surface thereof at a side of the reticle coincides with a Fourier transform surface (a pupil conjugate surface).

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Please replace the paragraph beginning at line 18, page 13, with the following rewritten paragraph:

There is disposed adjacent to the second focal point of the elliptical mirror 2 a shutter (for example a rotary shutter having four blades) which closes and opens a passage of the illumination light IL by a motor 38. A laser beam such as the excimer laser (KrF exciter laser, ArF exciter laser) and the like, or a high harmonic wave such as the metallic vapor laser or YAG laser may be used as the illumination light for exposure other than the high pressure mercury-vapor lamp 1.

Please replace the paragraph beginning at line 22, page 15, continuing to page 15, with the following rewritten paragraph:

Fig. 5© shows the reticle R according to the present embodiment. In the reticle R shown in Fig. 5©, reticle marks 64X and 64Y are formed as alignment marks at substantially central positions of two sections of a shading band 62 which surrounds a pattern area or region 61. The two sections of the shading band intersect each other at right angle. An image of the reticle marks are formed on the substrate or wafer W as wafer marks having a concave and convex pattern by projecting the image of the reticle marks onto the wafer and developing it. These reticle marks 64X and 64Y may be commonly used as alignment marks when the position of each shot area of the wafer W and the position of the reticle R is aligned or registered. These two reticle marks 64X and 64Y have the

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same structure (direction thereof is different from each other), each of which is formed by means of a shading film or coating of chromium or [etc.] the like positioned within transparent windows 63X and 63Y formed in the shading band 62. Moreover, the reticle R has two alignment marks 65A and 65B which are formed near outer periphery thereof in opposite relation and consist of two [cross like] cross-like shading marks. These two alignment marks 65A and 65B are used for aligning the reticle R (alignment of the position with respect to the axis of light).

Please replace the paragraph beginning at line 19, page 15, with the following rewritten paragraph:

As shown in Fig. 5(c), the reticle marks consist of a reticle mark 64X for detecting the position in [a] an X direction and a reticle mark 64Y for detecting the position in a Y direction. These reticle marks 64X and 64Y are constituted by five sub-marks disposed in a transparent or transmittivity portion. The reticle mark 64Y for detecting the position in the Y direction is turned [by 90 degree] 90° with respect to the reticle mark 64X for detecting the position in the X direction.

Please replace the paragraph beginning at line 1, page 16, with the following rewritten paragraph:

Fig. 5(d) shows a part of the structure of the reticle mark 64X for the X direction. In Fig. 5(d), the reticle mark 64X is structured by positioning, between adjacent transmittivity portions 66A, 66B, ... , each having a width in the X direction of not less than a predetermined value, sub-marks

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67A, 67B, ..., each having the same width as that of the transmittivity portion. Each sub0mark 67A, 67B, ..., is constituted by alternately disposing five slit-like shading films or membranes 68 and four transmittivity portions 69 with a predetermined distance in the X direction.

Please replace the paragraph beginning at line 12, page 16, with the following rewritten paragraph:

These sub-marks 67A, 67 B, ..., are spaced apart from each other with a distance of not less than a predetermined value. This distance, preferably, is determined considering a resolution of the alignment sensor. The distance between adjacent two sub-marks is determined so that a distance between two adjacent [two] sub-patterns of the wafer mark formed on the wafer mark formed on the wafer after sub-marks 67A, 67B, ..., on the reticle are exposed and transferred to the wafer, is not less than 2 μ m. The shape of the sub-marks 67A, 67B, ..., is not limited to that shown in Fig. 5(d). The reticle marks 64X, 64Y may be marks in which bright portions and dark portions are reversed.

Please replace the paragraph beginning at line 24, page 16, with the following rewritten paragraph:

The pitch distance between adjacent shading films 68 and the pitch distance between adjacent transmittivity portions 69 in the sub-marks 67A, 67B, ..., are determined so that an image of the sub-marks becomes a size of not more than the resolution of the alignment sensor when the sub-marks are transferred onto the wafer. Although the sub-marks 67A, 67B, ..., in the reticle mark 64X,

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according to the present embodiment is a regular pattern, they may be an irregular pattern. However, the distance between adjacent bright portions or the distance between adjacent dark portions in the irregular pattern are, preferably, determined so that an internal structure of a sub-pattern on the wafer formed by the sub-marks has a fineness of not more than the resolution of the alignment sensor used for detecting the sub-pattern when the sub-marks are transferred onto the wafer. The reticle marks 64X and 64Y can be formed by a well known pattern generator or an electron beam drawing device.

Please replace the paragraph beginning at line 13, page 17, with the following rewritten paragraph:

Referring again to Fig. 3, the reticle R is set on a reticle stage RS which is precisely controlled, the movement thereof in the direction (Z direction) along an optical axis AX (this axis coincides with an optical axis of the illumination optical axis) of the projection optical system 13. The reticle stage is also two-dimensionally movable and rotatable little by little in the horizontal plane which is perpendicular to the axis AX. The rotation of the reticle stage is precisely controlled. Disposed and fixed on an end of the reticle stage RS is a movable mirror 11m which reflects a laser beam from a laser interferometric measuring machine (laser interferometer). The position of the reticle stage RS is always detected with resolving power, for example, in the order of 0.01 μm by the laser interferometer. Disposed above the reticle R are [a] reticle alignment systems (RA systems) 10A and 10B which detect two cross-shaped alignment marks 65A and 65B formed on the reticle adjacent to the outer periphery thereof. The reticle R is positioned so that the center point of a

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pattern area 61 coincides with the optical axis AX of the projection optical system 13 by slightly moving the reticle stage RS on the basis of measured signals from the RA system 10A and 10B.

Please replace the paragraph beginning at line 17, page 18, with the following rewritten paragraph:

The wafer W is held by a vacuum suction on [an un-shown] a wafer holder (not shown) which is rotatable [little by little]. The wafer stage WS is structured so that it can move two dimensionally in step-and-repeat method by a motor 16. The wafer stage WS is stepped to the next shot position after transfer exposure of the reticle R for one shot area on the wafer W is finished. Disposed and fixed on [an] one end of the wafer stage WS is a movable mirror 15 which reflects a laser beam from a laser interferometer 15. The two-dimensional coordinates of the wafer stage WS is always detected with a resolving power, for example, in the order of 0.01 μm by the laser interferometer 15. The laser interferometer 15 measures coordinates of [a] an X direction and a Y direction of the wafer stage WS. A stage coordinate system (a stationary coordinate system) (X,Y) of the wafer stage WS is determined by the coordinates in the X direction and the Y direction. Namely, coordinate values of the wafer stage WS measured by the laser interferometer 15 are the coordinate values on the stage coordinate system.

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Please replace the paragraph beginning at line 1, page 20, with the following rewritten paragraph:

Provided at one side of the projection optical system 13 is an alignment sensor (hereinafter referred to as "Field Image Alignment system (FIA system)") which image-processes by [a] an off-axis method. In this embodiment, detection of the position of the wafer mark is performed by this FIA system. In this FIA system, a light emitted from a halogen lamp 20 is introduced into an interferometer 23 through a condenser lens 21 and an optical fiber 22. The light having a wavelength band to which the photoresist layer is sensitive and [a] an infrared wavelength band is cut off in the interferometer 23. The light having been passed through the interferometer 23 enters into an objective lens 27 of double telecentric type through a lens system 24, a beam splitter 25, a mirror 26 and a field stop BR. Light having emitted from the objective lens 27 is reflected by a prism (or mirror) 28 fixed on the periphery of the lower portion of a lens barrel so that an illumination field of the projection optical system 13 is not shaded, and irradiates the wafer W in the direction substantially perpendicular to the surface of the wafer.

Please replace the paragraph beginning at line 20, page 21, with the following rewritten paragraph:

There is provided at one side of an upper [portion] portion of the projection optical system 13 with an alignment sensor of a TTL (through the lens) system and the light from the alignment sensor 17 for detecting the position of the wafer mark is introduced into the projection optical system

through mirrors M1 and M2. The light for detecting the position is irradiated to the wafer mark on the wafer W through the projection optical system and the reflected light from the wafer mark is returned to the alignment sensor 17 through the projection optical system 13, the mirror M3 and the mirror M2. The position of the wafer mark on the wafer W is obtained from a signal obtained by photoelectrically converting the reflected light returned to the alignment sensor 17.

Please replace the paragraph beginning at line 17, page 22, with the following rewritten paragraph:

In Fig. 4, a laser beam emitted [from] from a light source (He-Ne laser source and the like) 40 is split by a beam splitter 41. A laser beam reflected by this beam splitter 41 enters into a first beam formation optical system (LIA optical system) 45 through a shutter 42. On the other hand, the laser beam having passed through the beam splitter 41 enters into a second beam formation optical system (LSA system) 46 through a shutter 43 and a mirror 44. Accordingly, the LIA system and the LSA system can be selectively used by suitably driving the shutters 42 and 43.

Please replace the paragraph beginning at line 19, page 23, and continuing onto page 24, with the following rewritten paragraph:

On the other hand, two laser beams reflected by the beam splitter 49 once cross each other at an opening of the field stop 51 by the objective lens 50 and then enter into the projection optical system 13 through the mirror M2 (in Fig. 3 mirror M1 is omitted). The two laser beams entered into

the projection optical system 13 once converge as a spot substantially symmetrical with respect to the optical axis AX on a pupil surface of the projection optical system 13 and then becomes beams which incline each other on both [side] sides of the optical axis AX with a symmetrical angle with respect to a pitch direction (Y direction) of the wafer mark on the wafer W, thereafter enter to the wafer mark from the two different [direction] directions with a predetermined crossing angle. Formed on the wafer mark are one-dimensional interference fringes which move with a speed corresponding to the frequency differential. Plus or minus (\pm) one-dimensional diffracted light generated in the same direction from the mark, i.e., in the direction along the optical axis, is received by the photoelectric detector 52 through the projection optical system 13 and the objective lens 50. The photoelectric detector 52 outputs the photoelectric signal SD having sine wave corresponding to cycle of change in bright and dark of the interference fringes to the LIA arithmetic processing unit 58. The LIA arithmetic processing unit 58 calculates a positional offset or displacement value of the wafer mark from the phase difference in waves of the two photoelectric signals SR and SD_w, and uses a positional signal PDs from the laser interferometer 15 to obtain a coordinate position of the wafer stage WS when the above positional offset value becomes zero.

Please replace the paragraph beginning at line 22, page 24, and continuing on to page 25, with the following rewritten paragraph:

The LSA optical system 46 includes beam expander, cylindrical lens and the like. The laser beam emitted from the LSA optical system 46 enters into the objective lens 51 through the beam

splitter 48 and 49. Moreover, the laser beam exited from the objective lens 50 once converges into a slit-like shape at an opening of the field stop 51 and then enters into the projection optical system 13 through the mirror M2. The laser beam entered into the projection optical system 13, passes through a substantially central [portion] portion of the pupil surface and thereafter is projected on the wafer W as elongated band-like spot light which extends in the X direction in an image field of the projection optical system and faces toward the optical axis AX.

Please replace the paragraph beginning at line 18, page 29, with the following rewritten paragraph:

As explained above, the surface on the wafer in which the predetermined circuit and the wafer mark 76X, 76Y are formed is flattened still more in order to form an upper layer circuit in steps 106 and 107. This flattening operation [my] may be performed in the same method as explained before, however, according to this embodiment, in the step 106 [a] an insulating film or membrane (or a metallic film or membrane, hereinafter referred to as a film to be flattened) 79 of an oxide silicon (SiO_2), and the like, is coated. In this stage, there are minute concave portions and convex portions in a surface 79a of the film to be flattened 79. Next in the step 107, a process for chemically and mechanically grinding or polishing the surface 79a of the film to be flattened is practiced. This chemical and mechanical polishing is a method for mechanically polishing or grinding the surface of the film to be flattened adding predetermined chemicals or water as occasion demands.

Please replace the paragraph beginning at line 12, page 33, with the following rewritten paragraph:

In a step 108, a photoresist is applied again on the wafer W having a film to be flattened 79 the surface of which is flattened by the process explained above. In this case, for example, a photoresist applying device (coater) of [the] a spin coat method in which thin film of the photoresist is formed on the wafer W by using centrifugal force is used. The wafer W on which the photoresist is applied is set on the wafer stage of the above mentioned projection optical system, a projection optical system adapted to practice the exposure method according to the present embodiment or a conventional pattern formation device. At this time the wafer marks 76X, 76Y are detected by the alignment sensor of the FIA system through flattened film and alignment of the wafer is performed.

Please replace the paragraph beginning at line 2, page 34, with the following rewritten paragraph:

Again, in the step 110, a new circuit pattern and, if occasion demands, a new wafer mark [are] is formed using another reticle. At this time, in a position at which the new wafer mark is formed there is no dish-like concave portion due to dishing phenomenon explained before and a stable wafer mark having no mark distortion is formed on the surface 80 of the film to be flattened 79 on the wafer.

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Please replace the paragraph beginning at line 9, page 34, with the following rewritten paragraph:

Figs. 6(a) and 6(c) show another embodiment of a wafer mark for the X axis of the FIA system which is used in the exposure method according to the present invention. Fig. 6(a) shows a wafer mark of a line-and-space pattern which is formed by arranging minute sub-patterns along the non-measuring direction. This wafer mark is constituted by line marks 81A, 81B and 81C each of which consists of a plurality of projections or convex portions 83 and a plurality of recesses or concave portions 82 having a width not more than a predetermined value. The line marks 81A, 81B and 81C are formed by alternately and separately arranging the concave portions 82 and convex portions 83 with a predetermined pitch in the Y direction. Fig. 6(b) shows a wafer mark in which minute sub-patterns are two-dimensional lattice shape. This wafer is constituted by line marks 84A, 84B and 84C each having minute lattice-shaped concave and convex pattern. The line marks 84A, 84B and 84C are separately arranged with a distance of not less than a predetermined value in the same manner as the line marks shown in Fig. 6(a). Fig. 6(c) shows a wafer mark in which minute sub-patterns are random dots shape. This wafer is constituted by line marks 85A, 85B and 85C each having dot-shaped projections or convex portions which are randomly arranged. The line marks 85A, 85B and 85C are separately arranged with a distance of not less than a predetermined value in the same manner as the line marks shown in Figs. 6(a) and 6(b). These alignment marks having minute sub-patterns can be used not only in the FIA system but also in the LSA system, the LIA system, and the like.

Please replace the paragraph beginning at line 1, page 36, with the following rewritten paragraph:

The exposure method according to the present invention can also be used in [a] an exposure apparatus of a step-and-scan method wherein exposure is performed scanning the reticle and wafer at the same time. Thus, the scope of the present invention [does] is not limited to the above embodiments and it is possible for those skilled in the art to take many modifications within the scope of the present invention.

Please replace the paragraph beginning at line 9, page 36, with the following rewritten paragraph:

According to the exposure method no dishing phenomenon is created above the alignment mark even after a flattening processing is performed. According, the creation of distortion in the detected light of the alignment mark is prevented when the alignment of the wafer is performed to increase the accuracy of the alignment. Moreover, it is not necessary to modify a mechanism in an exposing and transferring apparatus and therefore the structure thereof is simple.

Please replace the paragraph beginning at line 18, page 36, with the following rewritten paragraph:

In the case where the distance between adjacent convex portions of alignment mark is not less than 2 μm , the alignment mark can be detected by means of a conventional alignment sensor

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having ordinal resolution. If the distance between adjacent convex portions of the alignment mark is not less than $2\text{ }\mu\text{m}$, it is easy to create dishing phenomenon, but according to the present invention, creation of dishing is prevented.

Please replace the paragraph beginning at line 3, page 37, with the following rewritten paragraph:

[Further more] Furthermore, according to the substrate polishing apparatus of the present invention the film can be polished so that the film thickness of each pattern becomes symmetrical. Namely, as is clear [form] from Fig. 11, a polishing force (intensity of polishing) in regions R_{1X} , R_{2X} (hereinafter called as regions between patterns) between a pattern X_1 formed on the wafer 115 and other patterns X_2 , X_3 adjacent to the pattern X_1 do not deviate in one direction in the regions R_{1X} , R_{2X} and the surface 115a of the wafer 115 is [ground] grounded symmetrically in the regions R_{1X} , R_{2X} thereby making the film thickness 115b symmetrical. If patterns X_1 , X_2 and X_3 constitutes an alignment mark, the surface of film in the regions R_{1X} , R_{2X} between patterns sinks symmetrically. This reduce effects on detection of alignment mark.

Please add the following as the last full paragraph on Page 37:

While the invention has been particular shown and described in reference to preferred embodiments thereof, it will be understood by those skilled in the art that changes in form and details may be made therein without departing from the spirit and scope of the invention.

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August 16, 2001

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IN THE CLAIMS:

Please amend claim 12, as follows:

12. (Amended) A mask according to claim [7] 10, wherein said blight pattern is regularly arranged.

Please amend claim 13, as follows:

13. (Amended) A mask according to Claim [7] 10, wherein said blight pattern is irregularly arranged.

Please cancel claims 1-5, and 14-23 without prejudice or disclaimer.